Supplementary Information for

Disentangling Perceptual Awareness from Non-conscious Processing in Rhesus Monkeys (*Macaca mulatta*)

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This PDF file includes:

Materials and Methods

Figures S1 to S6

Table S1

Legends for Movies S1 to S2

Legends for Supplementary Data S1 to S5

Other supplementary materials for this manuscript include the following:

Movies S1 to S2

Supplementary Data S1 to S5

Materials and Methods

Animals

Test subjects: four adult (three male and one female; aged 7.5–8.5 years) rhesus monkeys (*Macaca mulatta*) served as subjects. Subjects were housed with a single pair or in triads, kept on a 12-h light/dark cycle, had unrestricted access to food 24-h a day, and controlled access to fluid during testing. Animals had a surgically implanted headpost (GreyMatter Research) for restraining their heads while tracking eye positions at 1,000 Hz (EyeLink, SR Research). Three monkeys participated in Experiment 2 and three monkeys in Experiment 4. All procedures were conducted in accordance with the National Institutes of Health guidelines and the Public Health Service's Guide for the Care and Use of Laboratory Animals, and with approval from the Yale University Institutional Animal Care and Use Committee.

Animal Experiments Apparatus

Animals sat in primate chairs (Precision Engineering) inside a testing room and viewed stimulus images alone on an LCD or CRT computer monitor positioned 110 cm away from the subject spanning 11 × 1.3 degrees of visual angle for a two-target view, and 2.2 * 1.3 degrees for a single target view. Before testing, each animal underwent a systematic calibration procedure. Horizontal and vertical eye positions were sampled at 1,000 Hz with an infrared eye camera. Stimuli were controlled by Psychtoolbox and Eyelink toolbox in MATLAB (Brainard 1997).

Pre-registration

All experiments were pre-registered before testing at https://aspredicted.org/. Monkey experiments were based on the human experimental pre-registered procedures using all trained and available monkeys of the lab at the time of testing. Pre-registration files are provided as Supplementary Data 1-5.

Human Participants

All human experiments were approved by the Yale Human Subjects Committee (#2000022495) and the Hebrew University Human Subjects Committee. We obtained informed consent from all participants who were told the nature and possible consequences of the studies. Following our pre-registered criteria for recruiting participants, a total of 145 participants participated in our human experiments. 113 Yale undergraduates participated for course credits in Experiments 1, 3, 5, 6 and 7 (63 females, mean age = 19)– 32 participants in Experiment1 (16 in the eye-tracker modality, 8 female, mean age =19.1 and 16 in a key press modality, 11 female, mean age =19); 37 +12 participants in Experiment 3 and 6 respectively (26 female, mean age =18.96), (13 participants of which were added to replace participants with scores >61% in the objective awareness test to complete the pre-registered group of 36 referred to here as the 'high confidence group', but also retained in the 'all participants group', also see pre-registration Supplementary Data 2, exclusion criteria and awareness tests description below); 16 participants of which performed with the eye tracking response modality and the rest with key press, as pre-registered; 12 participants in Experiment 5 (7 female, mean age =18.75); and 20 participants in Experiment7 (11 female, mean age =19.25). In addition, 32 participants (16 females, mean age = 27.8) participated in an online auxiliary control of Experiment 1. These participants participated online from the following locations: 6 from the USA; 6 from Portugal; 6 from Poland; 3 from the UK; 2 from Canada; 2 from Greece; 2 from Italy; 2 from Norway; 1 from Mexico; 1 from Hungary; and 1 from Spain.

Apparatus

In all experiments, stimuli were presented on a CRT or LCD monitor controlled by either Psychtoolbox extension for MATLAB (Experiments 1, 2, 3, 4, 6, and 7) or DirectRT experimental software (Experiments 5) or Gorilla online experimental package (Experiment1 unmasked auxiliary control). In Experiments 1 and 3 an identical EyeLink system that was used with the monkeys was fitted to our human participants to capture gaze tracking. Human participants sat inside a quite testing room, positioning their head within a stationary chin-rest, and viewed stimulus images on the computer monitor positioned 60 cm away, spanning 20 × 2.4 degrees of visual angle for a two-target view, and 4 * 2.4 degrees for a single target view. The unmasked auxiliary control of Experiment1 which was designed to test for facilitations only, was run online on participants' desktop computers with variable screen displays and participant distances.

Stimuli, Conditions, and Procedure

Experiment 1 tested the *spatial cueing paradigm* in adult humans. In this task, a treasure chest target appeared on the left or right of the screen and participants were requested to identify the target location as quickly as possible. Critically, 667ms prior to the presentation of the target, a grey star cue was presented in the opposite location either supraliminally for 250ms (and then masked by two white noise grey rectangles with grey stars within them, see Fig. 1*A* left panel), or presented subliminally for 17/33ms and then masked. The cue predicted the location of the target with a probability of 1 but in an incongruent manner – the targets always appeared in the opposite location. As a baseline control, we also presented two non-predictive cues, both in the supraliminal and subliminal conditions. Thus, the participants in this control condition could not use the spatial cues to predict the target location (Fig. 1*A* right panel). In the *subliminal condition*, in order to assess the optimal interval, cues were presented for 17ms for half of the participants, and 33ms for the other half. In all conditions, masked stars were slightly misaligned by few millimeters from the original cue location in order to avoid creating a motion sensation towards the new masked star in the no-cue location. Participants were exposed to 300 trials of supraliminal cues and 300 trials of subliminal cues in a counterbalanced block order, where half of the participants started with the subliminal condition and half with the supraliminal condition. Within each condition, 80% of the trials consisted of single star cues with an opposite target, and 20% of trials consisted of the two-star cues baseline control with a random target location. Trials were presented in a randomized order in blocks of 50 trials separated by a 15-sec break. In the second half of the subliminal and supraliminal conditions, we restricted the software not to allow for errors and wait until a correct response was made. This was done in order to minimize speed accuracy tradeoffs in case deviations in errors rates were to be found (yet we found that error rates were minimal 1.21% and did not deviate significantly between conditions). Half of the participants performed in the eye tracking response modality and half in the keypress response modality. In the eye tracking modality, participants needed to saccade and hold their fixation for 200ms on the chosen target in order to select it. Importantly, if participants gaze happened to be at the incorrect location at the moment of the target onset, they could still move their gaze to the correct target location before fixating, to select their final response. We preregistered that we will pool the two response modalities together if they are qualitatively similar or analyze them separately if they differ. We observed that the key-press modality in this specific task did not generate non-conscious response time effects (possibly since in keypress it may be solved using peripheral vision), and hence we report the key-press modality data separately in *SI Appendix* Fig. S1*A*.

Additional technical parameters included a fixation square appearing at the center of the screen for 500ms prior to beginning of each trial. Targets appeared on the screen until the participant made a selection. The next trial appeared after 500 ms. Participants received correct or error feedback by a 'cash register' sound and a coin image under the target if they were correct or a 'buzzer' sound and an X image below their choice if they were incorrect. Feedback was given for 1 second. Prior to the supraliminal or the subliminal conditions, participants were also exposed to a short 10-trial *congruent training phase* with two simultaneous target treasure chests on the screen when one of the targets had a green supraliminal star cue in it (as opposed to the grey star in the focal task). Participants were instructed to choose the target they thought contained the treasure. In this training phase, the treasure was always hidden under the chest that contained the star. This *congruent training phase* was included in order to help create (or re-create) a dominant automatic response towards the star location, and was presented prior to the beginning of both conditions. Following the completion of the supraliminal and subliminal conditions, participants were asked if they used any type of strategy to perform this task quickly and participants' responses were recorded with particular attention to any reference they made, if any, about the star cues. At the end of the session participants were presented with a final *objective awareness test* block of 64 trials with two simultaneous treasure chests that mask a subliminal one-star cue presented in one of them for 17/33ms (corresponding to the subliminal interval the participant received). In this test, participants were specifically instructed that stars will be flashing quickly on the screen and their task is to select the chest that the star flashed in, and if they were not sure then they should just guess. Targets appeared on the screen for 5 seconds or until the participant had made a response. Participants did not receive error/correct feedback in the *objective awareness test*, and their accuracy was assessed using the binomial distribution compared to random performance.

Experiment 1 unmasked keypress auxiliary control: This auxiliary control experiment tested a variation of the *spatial cueing paradigm* without masking in adult humans. The stimuli, timing, and conditions were the same as in the eye-tracking Experiment 1 except that participants were run with a key-press response modality, and with cues of 33ms and 250ms without masking. We anticipated that removing the masking will now increase the number of participants becoming aware of the 33ms cues and their predictive value, and thus could exert similar facilitations to the ones observed in aware humans in the 250ms condition (see also preregistration Supplementary Data 5). Since the keypress modality in the current apparatus is suited to detect only facilitations rather than interferences (the task is solvable using peripheral vision, see results of Experiment1 with the keypress modality in *SI Appendix* Fig. S1*A*, and also preregistration Supplementary Data 5), we tested participants with half the number of trials (150 trials in each cue interval) as we anticipated a facilitation will be easily identified in few trials in aware participants.

Experiment 2 tested the *spatial cueing paradigm* in monkeys. The stimuli, timing and conditions were the same as in Experiment1, whilst the duration of gaze fixation for selection was individualized per monkey (range 150-250ms). Correct or error feedback was the same as in experiment 1 with the addition of juice reward drops that were given per correct response. Amounts of juice per correct response were adjusted to the individual monkey's motivation but kept constant through the whole session. In addition, monkeys received a smaller juice reward upon initiation of the experimental trial by fixating gaze on the fixation square for the specified duration of time that also initiated the experimental trial. After feedback was given the next trial appeared after 2 seconds. Monkeys participated in blocks of 50 trials separated by 30-second breaks. Two monkeys

started with the supraliminal condition and one monkey started with the subliminal condition. Two of the monkeys performed the subliminal condition with 17ms (60hz LCD monitor) and one monkey with 13ms (75hz CRT monitor). Monkeys participated in the task in a single session or multiple sessions that were run and stopped based on their motivations. Monkeys performance on the single cue conditions were compared to the two-star baseline control in separate fixed blocks. As in Experiment1, prior to beginning the supraliminal or subliminal conditions the monkeys first participated in the *congruent training phase* after completing at least 80% correct in the last 25 trials.

Experiment 3 tested the *forced guessing paradigm* in adult humans. In this task, participants had to guess where a reward was hidden in one of two simultaneous treasure chest targets. As in the previous experiments, a grey star cue was presented within one of the targets, and the reward was again always hidden in the opposite location. In the *subliminal condition*, the visible cue and targets were immediately masked by two identical treasure chests that contained white noise grey rectangles with a grey star within each of them (see Fig. 3*A*). Masked stars were again slightly misaligned by few millimeters from the original cue location in order to avoid creating a motion sensation towards the new masked star in the no-cue location. In order to assess the optimal subliminal interval, half of the participants received this condition with 17ms, and half with 33ms. The participants had to choose in which of the two treasure chests they think a reward was hidden. In the eye tracking modality, they just had to look at the treasure chest they thought had the treasure for 200ms to select it and in the key press modality they needed to press the corresponding key on the keyboard. Before every trial, a fixation square appeared on the screen for 500ms. In both supraliminal and subliminal conditions, the reward was always hidden in the treasure chest that did not contain the star cue. Participants received correct/error feedback after each trial as in Experiment 1. The supraliminal condition consisted of 30 trials, and the subliminal condition consisted of 385 trials divided into two sessions of (165 and 220 trials) and blocks of 55 trials separated by 15 second breaks. Half of the participants started with the supraliminal condition and half with the subliminal condition. Following the completion of the supraliminal and subliminal conditions, participants were asked if they used any type of strategy to perform this task and participants responses were recorded with particular attention to any voluntary reference they made if any to the star cues. In addition, following the *subliminal condition*, they were then asked specifically if they had seen any flashing star cues, and if so did they help them in anyway. As in Experiment1, before participating in each if the conditions participants preformed in 30 trials of the *congruent training phase* with supraliminal stimuli where the rewarding target was the one containing the green star (as opposed to the grey star in the focal task). This training task was included in order to help creating (or re-creating) a dominant automatic response towards the star location, and was presented prior to the beginning of both conditions. The targets were present for 5 seconds or until the participant made a response. The next trial appeared after 500ms. As in Experiment1, at the end of the experiment participants received the *objective awareness test* to assess their ability to see the location of the subliminal cues upon direct instruction.

Experiment 4 tested the *forced guessing paradigm* in monkeys. The stimuli, timing and conditions were the same as in Experiment3, whilst the duration of gaze fixation for selection was individualized per monkey (range 150-250ms), and feedback and rewards were the same as in Experiment2 and included individualized per monkey juice rewards. After feedback was given, the next trial appeared after 2 seconds. Monkeys participated in blocks of 55 trials separated by

30-second breaks. In the *supraliminal condition*, monkeys were tested until they reached a success criterion of 80% correct in the last 25 consecutive trials (P=0.003 at the binomial level) which automatically stopped the session by the software if met. As in Experiment 3, the *subliminal condition* consisted of 385 trials or stopped if the monkey reached the success criterion. Monkeys were run in a single session or in multiple depending on their motivation. One monkey started in the subliminal condition, and two monkeys started in the supraliminal condition. One of the monkeys which started in the supraliminal condition has portrayed low motivation to perform the task. After being exposed to 1625 supraliminal incongruent trials in four different sessions he made a choice in only 238 trials (<15% of overall trials exposed). The monkey was therefore excluded due to lack of motivation and was not exposed to the subsequent subliminal condition. One monkey preformed the subliminal condition with 17ms and another with 33ms. As in Experiment3, before participating in each of the conditions, monkeys preformed in the *congruent training phase* with supraliminal stimuli where the rewarding target was the one containing a green star (as opposed to the grey star of the focal task), until reaching the success criterion of 80% correct in the last 25 trials. This training task was included in order to help create (or re-create) a dominant automatic response towards the star location, and was presented prior to the beginning of both conditions.

Experiment 4 auxiliary control: This auxiliary control was identical to Experiment 4 except we presented the subliminal incongruent condition to monkeys directly after they completed the supraliminal incongruent condition without prior congruent training between them in one long session. This long session consisted of a congruent training phase, then the supraliminal incongruent condition, in which monkeys established learning (of at least 80% performance) in choosing *opposite* of the cue, and then directly performed in the subliminal incongruent condition. This was performed in order to examine whether the prior congruent training is necessary in order to observe below random performance in the subliminal incongruent condition. Yet since this unique control configuration required completing several long conditions in a single session, only one of our monkeys (monkey number #1) managed to finish this entire long control experiment. The second monkey (monkey number #2) reached criterion in the supraliminal condition in 453 trials, and then managed to perform in only 80 trials out of the 385 of the subliminal condition before losing motivation to continue the session. That monkey scored an overall of 48.7%, before completing the full condition.

Experiment 5 addressed an alternative explanation that participants in the *subliminal condition* might be aware of only a small number of trials, a number that is not enough for participants to learn the rule successfully but enough to show a significant cueing effect. To test if participants can learn the incongruent rule with only few aware trials, we exposed a group of human participants to the *forced guessing paradigm* (see Experiment 3) with a small percentage of supraliminal cued trials (20%) randomly intermixed within 80% unsolvable non-cued trials. As in Experiment 3, the experiment included 385 trials in 7 blocks of 55 trials separated by 15 second breaks. 80% of the trials consisted of two treasure chests with white noise rectangles and grey stars within them, while 20% of the trials consisted of a two treasure chests of which only one of these had a grey star cue within it on one of the sides (as in Fig. 4*B*, the subliminal condition.), but were masked after 250ms with the same two treasure chests with white noise and grey stars within them. Participants where requested to guess in which of the two treasure chests was the reward by pressing the corresponding key on the keyboard and received feedback if they were correct or

wrong. As in Experiment 3, the reward was always hidden in the chest opposite of the cue on cued trials and was random in non-cued trials. We predicted that even though the majority of trials will be impossible to solve, many participants would be able to see the 250ms cues when they appear and learn to perform well on these trials.

Experiment 6 tested a concern that the subliminal stimuli were simply less salient and thus harder to learn than supraliminal cues. In order to test this possibility, *Experiment 6* tested a subset of human participants in the Experiment 3 *forced guessing paradigm* after informing them, halfway through the *subliminal condition*, about the presence of quick flashing cues. The stimuli, timing, and procedure was exactly as in Experiment 3. Participants in this control group performed the subliminal condition before the supraliminal condition, and with 33ms either with the keypress response modality or the eye-tracking response modality (determined based on the eye-tracker availability, and participants' acceptable calibration to the system, as pre-registered, see Supplementary Data 2). After performing in the first subliminal session (165 trials) participants were asked if they used any type of strategy to perform the task, and after recording their voluntary response, they were specifically asked if they had seen any flashing stars. After which the participants were informed that a star cue is indeed flashing very quickly in one of the treasure chests and if they will be able to see it, they can use it to help them perform the task very efficiently. Participants were told that it would be very hard and if they are unsure to just guess. Participants were not informed that the cue would be opposite of the reward. Participants then preformed in the second subliminal 'informed' session (220 trials). At the end of which were asked again if they had any type of strategy to perform the task; asked if they saw the star cue; and asked if this cue helped them in anyway. Subsequently they performed in the supraliminal condition. As in Experiment 3, participants performed in the *congruent training phase* immediately prior to the subliminal condition and prior the supraliminal condition.

Experiment 7 In order to better understand the processes governing the task, Experiment 7 completely removed the learning aspect from the *forced guessing paradigm*, instructing participants from the very beginning to choose the *opposite* location of the cue if they see it, and also gauged participants awareness after every trial. The stimuli and timings were the same as in Experiment 3. Participants were informed at the beginning of the task that a star cue would flash quickly in one of the sides and the reward will always be on the opposite location of the cue. Participants were requested to try to see the cues and select the opposite chest using the corresponding key on the keyboard as accurately as possible, and if they were not sure to just guess. After selecting, participants were immediately gaged after each trial with the question of how sure they are that they saw the cue location on a scale from 0 to 3, where 0 is 'I saw nothing at all' to 3- 'I saw it clearly'. After reporting their subjective awareness participants received correct/error feedback on their previous choice. Participants took part in two sessions. The first consisted of 17ms cues in 5 blocks of 40 trials each, and the second session with a random mix of cue intervals 17, 33, 50, and 100 milliseconds, in 5 blocks of 40 trials randomly intermixed. As in in the previous experiments, before every block in the task participants were exposed to 10 trials of the *congruent training phase* with green star cues in attempt to enhance a dominant/automatic/intuitive response towards the star.

Data analysis

Experiment1 and 2 Response time was measured from the onset of the target. To correct for eye-tracking reading errors we allowed for response times up to 3500ms (98.4% and 100% of trials in Experiment 1 and 2 respectively). In addition, we excluded selections of the incorrect location from the two possible target location alternatives (1.12% and 1.29% in the subliminal condition and in the supraliminal condition in Experiment1 with the eye-tracking modality, and 1.49% and 0.89% in the keypress modality; and 9.3% in the subliminal condition and 7.9% in the supraliminal condition in Experiment2), and response times deviating more than +-2 standard deviations from the block mean, as pre-registered, see Supplementary Data 1 (5.63% and 4.51% in the eye-tracking and keypress modalities of Experiment 1, and 4.63% in Experiment 2). All response time statistics were performed on log transformed response times with an added constant of 100ms to avoid a log of 0, and using linear mixed models, see parameters included in the models below. In Experiment1, cue interval (17ms vs. 33ms) did not play a significant role, $F(2,29.97)= 0.13$, $P=0.87$, nor did order of conditions (subliminal or supraliminal condition first), $F(2,29.97)= 1.97$, $P=0.157$, hence intervals and orders were pooled, see also pre-registration Supplementary Data 4.

- Analyses of Fig. 1*B* and 2*B* consisted of linear mixed models on log response time with condition (supraliminal/subliminal), condition*trial, and intercept as fixed factors, with trial and condition as repeated measures, and a random intercept of the individual monkey/subject using a maximum likelihood estimation model via the SPSS V18 statistical software.
- Analysis of Fig. 1*C*; and *SI Appendix*, Fig. S1*A* consisted of linear mixed models on log response time with cue (single star/two star), cue * order, cue*interval, and intercept as fixed factors, with trial, cue, order, and interval as repeated measures, and a random intercept of the individual monkey/subject using a maximum likelihood estimation model via the SPSS V18 statistical software.
- Analyses of Fig. 2*C*; and *SI Appendix*, Fig. S1*B,* and Fig. S2*A* consisted of linear mixed models on log response time with cue (single star/two star) and intercept as fixed factors, with trial and cue as repeated measures, and a random intercept of the individual monkey/subject using a maximum likelihood estimation model via the SPSS V18 statistical software. The fastest monkey performing in the supraliminal incongruent cue condition (Fig. 2*C*, grey dot, mean=179ms) did not participate in the supraliminal two-star baseline condition the same day due to lack of motivation and did not complete that condition due to assignment to planned critical other studies and the time that had passed. If we substitute in the statistical analysis that monkey's missing two-star baseline condition with the monkey's subliminal two-star baseline (mean=302), it remains highly significant at ($F(1,3863)=208.14$, $P<0.0001$).
- Analyses of Fig. 1*E*; 2*E* and *SI Appendix*, Fig. S2*B* consisted of linear mixed models on mean gaze frequency with location (cue location /opposite no-cue location) and intercept as fixed factors, with trial and location as repeated measures, and a random intercept of the individual monkey/subject using a maximum likelihood estimation model via the SPSS V18 statistical software. On 2 of the 17 analyses the maximum likelihood (ML) estimation did not converge even after 1000 iterations and did not reach a final or intermediate solution (no statistical p-value was reported by the software). As a result, we used a restricted maximum likelihood (REML) estimation model that showed convergence. Performing all converging analyses with an REML rather than ML estimation keeps all analyses highly significant to a similar extent. In the monkeys' *supraliminal condition*, the last 200 trials have been included, after the learning have taken place (see *SI Appendix,* Fig. S3 *A-C*).

Experiment 1 unmasked keypress auxiliary control: The data analysis procedure was the same as in Experiment 1. We excluded selections of the incorrect location from the two possible target location alternatives (1.93% with 33ms cues and 1.59% with 250ms cues); and response times slower than 2 standard deviations from the block mean (5.98% with 33ms cues and 6.15% with 250ms cues), as pre-registered, see Supplementary Data 5. In addition, 9 participants which attested having diagnosed with or believed they might have an attention deficit, were excluded and replaced based on our pre-registered exclusion criteria.

Experiments 3 Order of conditions (subliminal or supraliminal condition first) did not play a role ($t<1, P=0.90$), nor did cue interval (17ms vs. 33ms), ($t<1, P=0.98$), nor did response modality (eye tracking/keypress), ($t<1, P=0.33$). Therefore, participants accuracies collapsed across the two orders, intervals, and response modality were analyzed for deviation from an expected random distribution of participant accuracies, see also pre-registration Supplementary Data 2. The first session (165 trials) of the subliminal condition of the informed participant group before they were informed was also included, as pre-registered, see Supplementary Data 2.

Experiments 4 Accuracy was calculated based on the % of correct responses from the total trials the monkeys made a choice in that condition, unless if the monkeys reached the stopping criterion of 80% in the last 25 trials, which determined successful learning of that condition, $P=0.003$.

Experiment 5 Accuracies were calculated from the critical single star cued trials of interest only.

Experiment 6 Accuracies of the first session (165 trials) of the *subliminal condition* before participants were informed were compared to accuracies of the last session (220 trials) of the *subliminal condition* after participants had been informed with emphasis on the peak consecutive 25 trials if participants reached the 80% success criterion.

Experiment 7 Participant accuracies were pooled based on participants ratings if they saw the cue location clearly (2-3 ratings) versus they did not see at all the cue location (0 ratings). As pre-registered, we analyzed separately the first fixed 17ms session and the second mixed interval session. We hypothesized that non-conscious effects will likely be stronger in the first fixed interval session blocks (e.g., due to training; creating an opposite dominant response; or improving participants visual subliminal threshold, as pre-registered, see - Supplementary Data 4) and indeed this is what we obtained. Hence, we considered only the first fixed 17ms session in this report. To allow for a meaningful comparison of awareness effects, we desired to have a minimum of 20 trials with ratings of 0 and of 2-3, (see also pre-registration - Supplementary Data 4). For this reason, for participants that had fewer than 20 trials rated as 0 or 2-3 in the first 17ms session we included trials from the second mixed block session of that same 17ms interval with the same rating. Even so, we still remained with a high proportion of participants with <20 trials with either 0 or 2-3 ratings (45% of participants), hence we allowed for a minimum of 6 trials in each category (M=75 trials, SD=58 for 0 ratings and M=60, SD=48 for 2-3 ratings), and excluded 3 participants that had only 1,3 and 4 -trials with 0 ratings, see also preregistration - Supplementary Data 4.

Awareness Tests: In Experiments 1 and 3 we used the binomial distribution to determine whether each participant performed better than chance on the *objective awareness test* and excluded from the high confidence analyses all those participants who did with accuracy >61% which is statistically significant at $P<0.05$ in the binomial test (4 and 13 participants in Experiments 1 and 3 respectively), yet note that all the effects remain even when including these participants. We additionally excluded participants who reported subjective awareness of the subliminal cues and to have reported using them in solving the task (2 participants in Experiments 1). Yet, note that since the predicted effects in the *subliminal condition* is in the opposite direction to that of the

supraliminal condition, worries about selection (41) do not hold here. in fact, if we mistakenly categorize subjects as unaware, we are deflating the anticipated effect, not inflating it.

Data visualization and heat maps. Heatmaps were generated based on view frequencies in MATLAB. Gaze position was normalized to the pixel dimensions of the screen; subsequently, histogram frequencies were computed by binning the continuous gaze data in time and space. For position, bins of 1% of the display were chosen (correspond to the proportion of the screen width and height in pixels); for the time dimension, 10ms bins were used. Histogram images were smoothed by convolving them with a Gaussian kernel with a mean of 0 and a standard deviation of 2. The kernel weights were normalized to sum of 1. Videos of gaze behavior during the task (Movies S1–S2) were constructed by overlaying the gaze position signal, represented as a filled circle, atop an accurate reconstruction of the task.

Figures

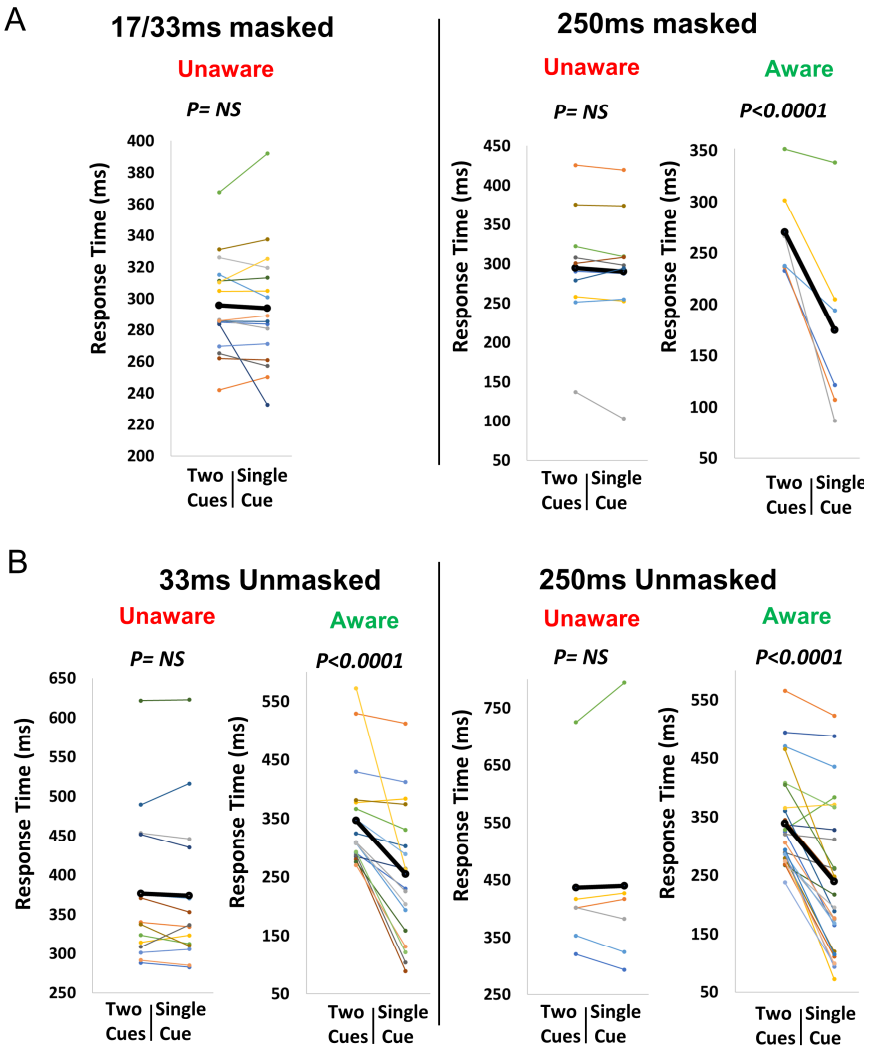


Fig. S1. Extended results of human participants performing the spatial cueing paradigm with a *keypress* modality (suited to detect only facilitations) with or without masking. (*A*) Individual participants' response time (ms) to respond to the target with *masked* 17/33ms or 250ms cues, as a function of their reported awareness of the cue's predictability. Plotted are single incongruent cues versus the two non-predictive cues baseline. Thick black lines indicate mean response time. Only participants which became *aware* of the predictive value of the cues (N=6 performing with 250ms masked cues) displayed a facilitation ($F(1,3105)=363.51$, $P<0.0001$). Participants performing with 17/33ms or 250ms masked cues which were not aware of the predictive value of the cues did not display a facilitation (N=16, $F(1,10201)=0.73$, $P=.39$; and N=10, $F(1,2805)=0.8$, $P=.37$ respectively). (*B*) Individual participants' response time (ms) to respond to the target of participants with *un-masked* 33ms or 250ms cues as a function of their reported awareness of the cue's predictability. Plotted are single incongruent cues versus the two non-predictive cues baseline. Thick black lines indicate mean response time. Only participants which became *aware* of the predictive value of the cues (N=18 with unmasked 33ms cues, and N=26 with unmasked 250ms) displayed a facilitation ($F(1,4631)=269.08$, $P<0.0001$; and $F(1,3651)=341.45$, $P<0.0001$ respectively). Participants which were not aware of the predictive value of the cues did not display a facilitation (N=14, $F(1,1955)=1.67$, $P=0.2$ with unmasked 33ms cues; and N=6, $F(1,834)=2.37$, $P=.12$ with unmasked 250ms cues).

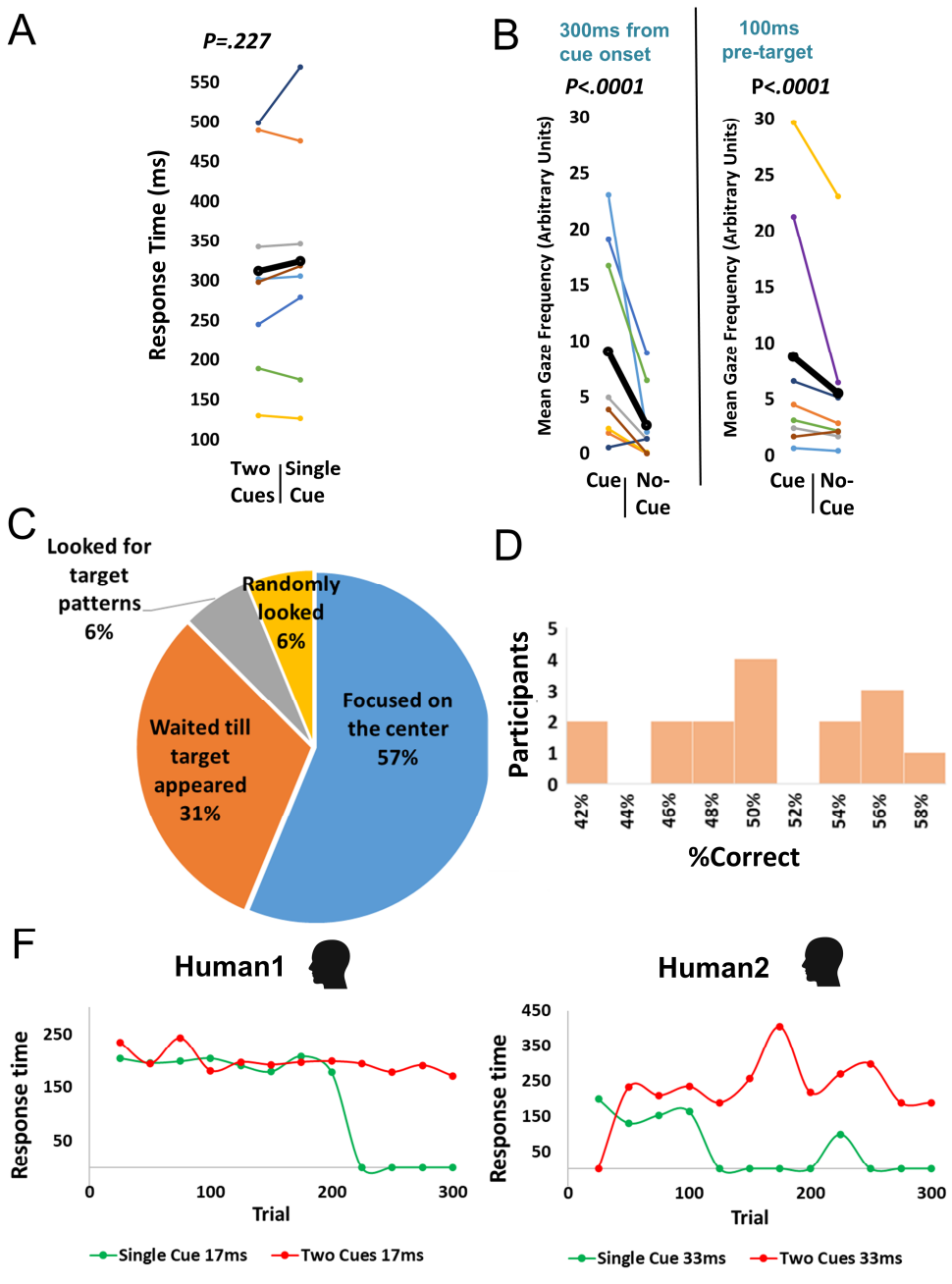
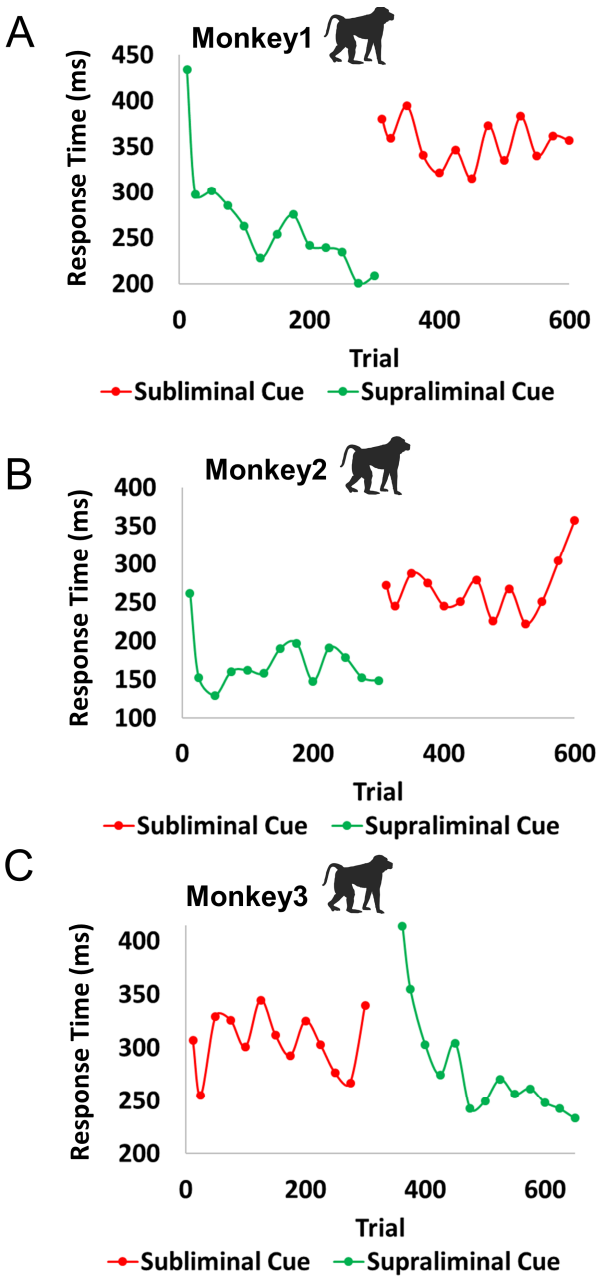


Fig. S2. Extended results of eye-tracked human participants in the spatial cueing paradigm. (*A*) Individual participants' response time to respond to the target of participants in the *supraliminal condition* who reported they were not aware of the cue's predictability, plotted following a single supraliminal incongruent cue versus two non-predictive supraliminal cues baseline. Thick black lines indicate mean response time. (*B*) Mean gaze frequency in the cue location and opposite no-cue location of the participants in the *supraliminal condition* who were not aware of the cue's predictability, during the first 300ms from cue onset (left panel), and in the last 100ms prior to the target appearance (right panel). Thick black lines indicate mean gaze frequency. Gaze frequency is measured as the mean duration of gaze within the specified time slots across trials and is presented in arbitrary unites – larger numbers signify higher frequency of gaze in that location. (*C*)

Distribution of participant responses of the strategies they used to quickly identify the target in the *subliminal condition* based on their self-reports. None of the participants included reported observing cues or using them in anyway. (*D*) Distribution of participants accuracy performance to identify specifically the subliminal cues location in the *objective awareness test* when requested to do so at the end of the experiment. Participants performance was no different than chance at the binomial individual level, or at the group level, t(15)=1.04, *P*=0.31.(*F)*: Median response time of two human participants that became aware of the subliminal cues during the task as attested by their self-reports. Plotted for single cues versus two cues baseline control through the progression of the task.



480

481 **Fig. S3.** Individual monkey's response times in the spatial cueing paradigm. (*A*-*C*) Response times
482 of the individual monkeys in the supraliminal incongruent cue condition (green marker) and in the
483 subliminal incongruent cue condition (red marker). Monkeys 1 and 2 performed in the supraliminal
484 condition first and monkey 3 performed in the subliminal condition first.

485

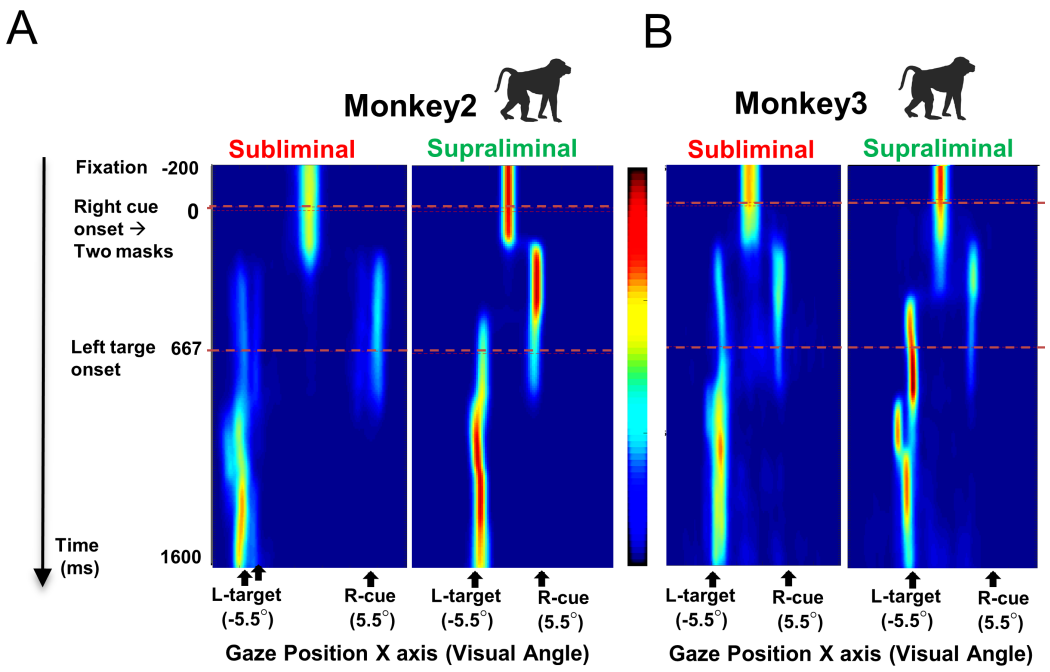


Fig. S4. Individual monkey's eye tracking in the spatial cueing paradigm. (*A-B*) Heatmap of individual monkey's gaze frequencies of all trials plotted as right cue –> left target trials (left cue –> right target trials are inversed and presented as well). Y-axis corresponds to time in milliseconds and the X-axis to the monkey's gaze position on the horizontal axis on the screen. Warm colors represent higher frequency of gaze to that location across trials. Upper dashed line represents the onset of the cue and the bottom dashed line the onset of the target. Monkey 2 and 3 gaze plots are presented. Monkey 1 gaze plot appears in Fig. 2*D*.

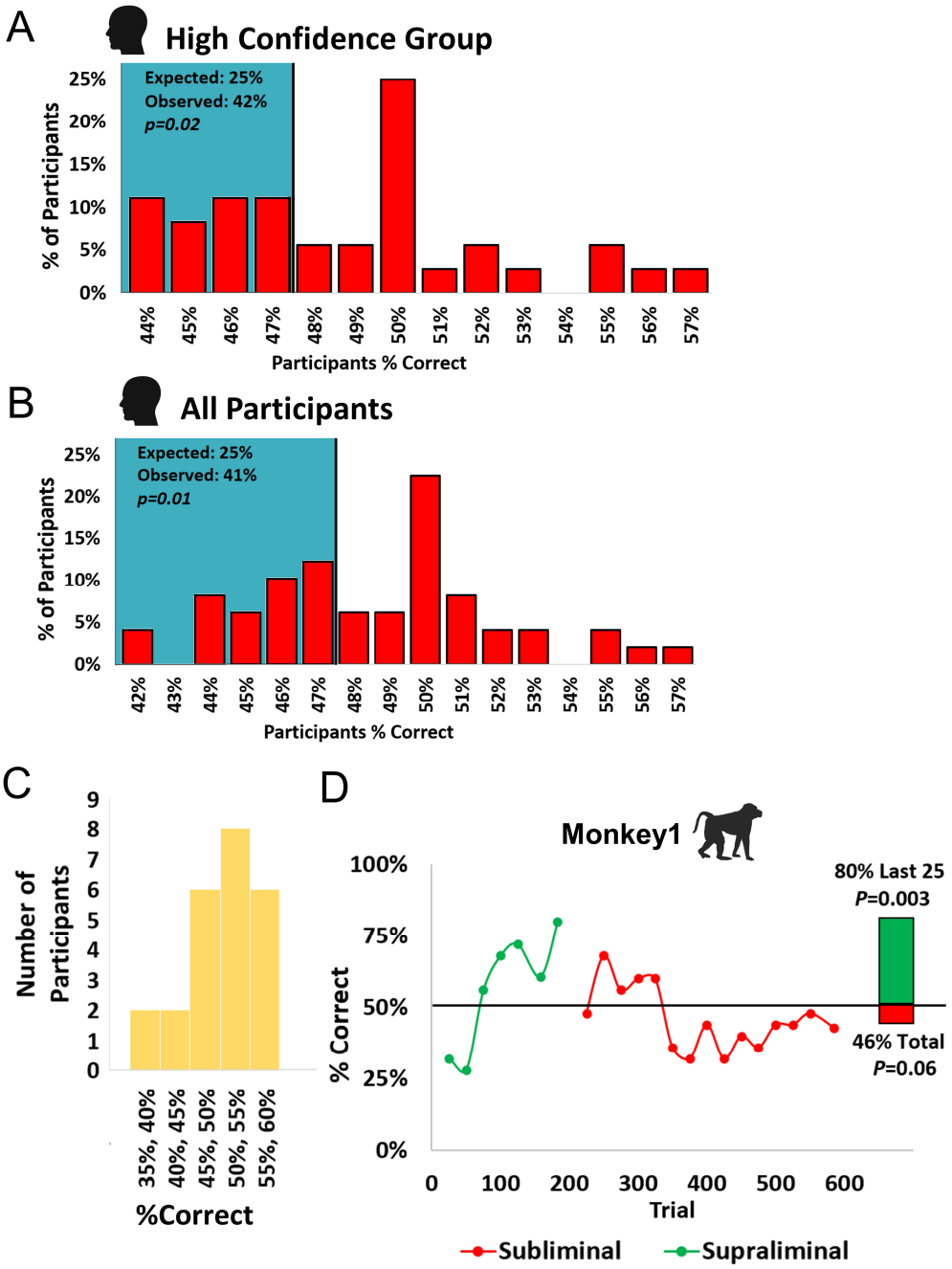


Fig. S5. Extended results in the forced guessing paradigm. (*A*) Distribution of participant accuracies of the 'high confidence group' in the *subliminal condition*. For each participant, a binomial probability p-value of the accuracy score was computed based on the number of correct trials out of the number of experimental trials. In order to assess if the obtained p-values differ significantly at the group level, we partitioned the p-value probabilities to quartiles (e.g., for scores < 50% a binomial p-value of 0.1 was positioned in the lowest quartile, a p-value of 0.4 in the mid low, and the same approach was taken for accuracy scores > 50% for the high quartiles). The chi square statistic was computed compared to the expected even distribution of quartiles. As hypothesized and pre-registered (supplementary data 2), a higher proportion of participants (42%) with accuracies that are expected at the first lowest probability quartile (25%) was observed,

$\chi(1)=5.33$, $P=0.021$. (*B*) Distribution of the 'all participant group' accuracies in the *subliminal condition*. A higher proportion of participants (41%) with accuracies that are expected at the first lowest probability quartile (25%) were observed, $\chi(1)=6.54$, $P=0.011$, calculated based on a partition of quartiles of participants binomial probability p value accuracy scores, compared to the expected even distribution of quartiles. (*C*) Distribution of the 'high confidence group' accuracy to identify specifically the subliminal cues location in the *objective awareness test* when requested to do so at the end of the experiment. Participants performance was no different than chance at the binomial individual level, or at the group level, $t(23)=0.795$, $P=0.435$. (*D)* Performance of monkey1 in the subliminal incongruent condition (red marker) *directly* after learning the supraliminal incongruent condition (green marker) without prior congruent training between these sessions. After scoring slightly above chance temporarily, the monkey quickly returned to perform much like how it performed in the original experiment, scoring 40% in the last 260 trials ($P=0.00078$, Binomial test), and with an overall total of 46% throughout the entire session ($P=0.063$, Binomial test).

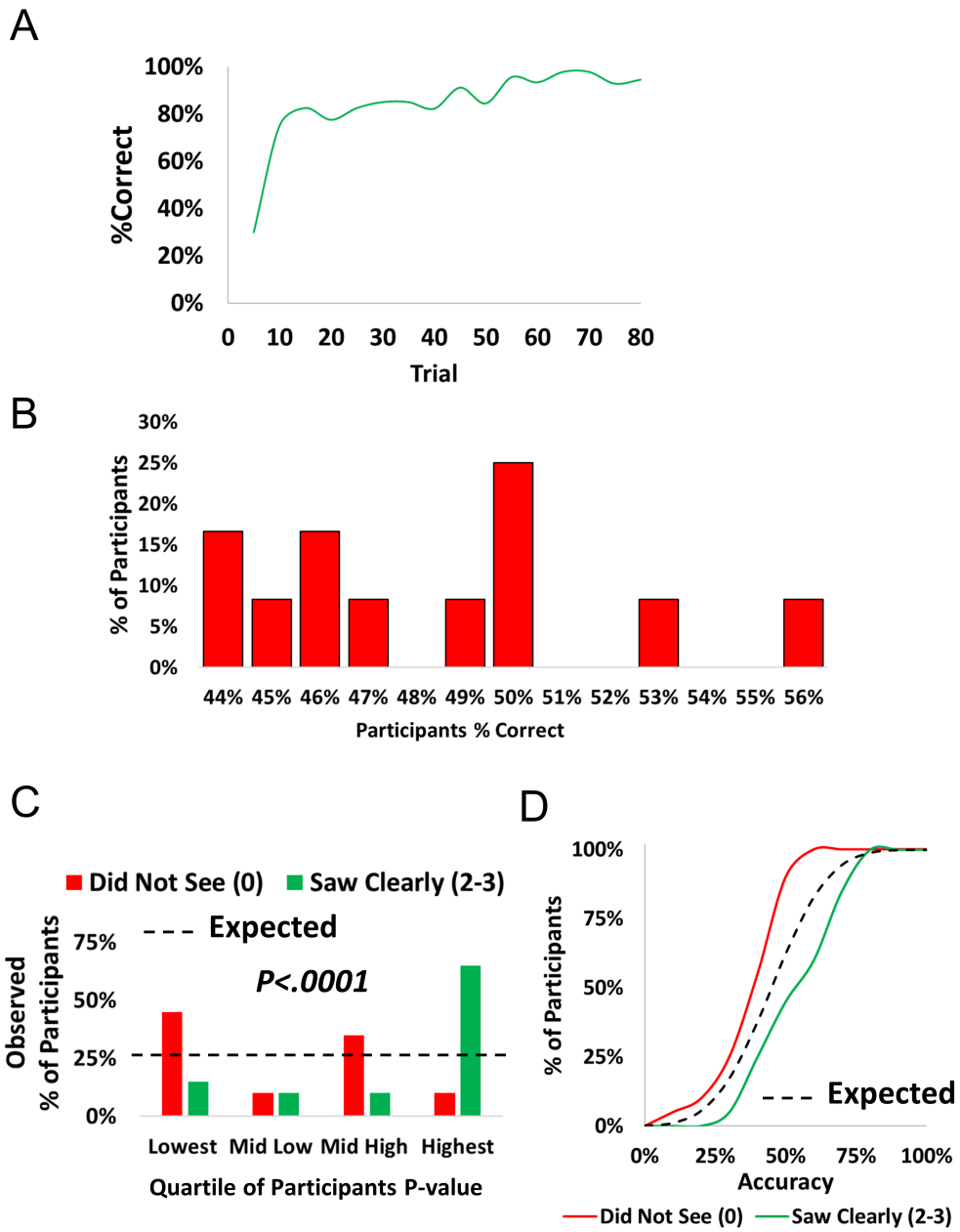


Fig. S6. Extended results of the control experiments in humans. (*A*) Mean accuracy of aware participants with supraliminal cues throughout the progression of Experiment5. Accuracy is calculated for every 5 consecutive intermixed supraliminal trials. (*B*) Distribution of participants accuracies in Experiment 6 in the first subliminal session (165 trials) before participants were informed about the presence of the cues. (*C*) Distribution of participants accuracy p-values in Experiment 7 in quartiles of the binomial distribution probabilities of each participant on trials they reported they did not see (0 ratings), (red bars); and on trials they reported they saw the location of the 17ms cue (2-3 ratings), (green bars), versus an expected even distribution of quartiles of participants scores (dashed line). For each participant, a binomial p-value probability of the accuracy score was computed based on the number of correct trials out of the number of

trials with the respective rating. In order to assess if the obtained p-values differ significantly at the group level, we partitioned the p-value probabilities to quartiles (e.g., for scores < 50% a binomial p-value of 0.1 was positioned in the lowest quartile, a p-value of 0.4 in the mid low, and the same approach was taken for accuracy scores > 50% for the high quartiles). As hypothesized and pre-registered (supplementary data 2), the chi square statistic was computed compared to the expected even distribution of quartiles, $\chi(3)=24.8$, $P<0.0001$. (*D*) Cumulative distribution function of participants accuracies in Experiment 7 is presented as a function of participants ratings of seeing the subliminal cue (red marker – did not see 0 ratings, and green marker – saw clearly 2-3 ratings) versus an expected random distribution of participants scores (dashed line).

Table S1. Summary of human experiments demographics and pre-registered exclusion criteria.

Human Experiment	Number of Trials	Pre-registered N (Sequential Testing Minimum)	Mean Age	Females	Excluded Based on Pre-registered Criteria: Replaced/Retained
Experiment 1	300 Supraliminal + 300 Subliminal	16 eye tracking (+ 16 keypress)	19.05	19	2: Reported seeing and using the cues; 4: Scored >61% in objective awareness test. All replaced
Experiment 1 Unmasked Control (Keypress)	150 with 250ms cues + 150 with 33ms cues	32 (Online Keypress)	27.78	16	9: Attested having an attention deficit. Replaced
Experiments 3 + Control Experiment 6	30 Supraliminal + 385 Subliminal	24 + 12 Respectively	19.96	26	13: Scored >61% in objective awareness test. Replaced in 'High Confidence Group' (N=36); Retained in 'All Participants Group' (N=49)
Control Experiment 5	385 (77 Supraliminal Cued + 308 Non-cued)	12	18.75	7	0
Control Experiment 7	400	20	19.25	11	3: Fewer than 6 trials rated as 0 - not seen. Replaced

Movie S1

Representation of the actual experimental session of one of the monkeys participating in the *spatial cueing paradigm* in *Experiment 2* during a supraliminal incongruent block with single cues only, overlaid with the monkey's real time gaze (red dot) in that session. One complete block of 50 trials is shown. Correct and error feedback sounds are absent, but were present in the actual task.

Movie S2

Representation of the actual experimental session of one of the monkeys participating in the *forced guessing paradigm* in Experiment 4 during a subliminal incongruent block, overlaid with the monkey's real time gaze (red dot) in that session. One complete block of 55 trials is shown. Correct and error feedback sounds are absent, but were present in the actual task.

Supplementary Data1

Pre-registration of the spatial-cueing paradigm

Supplementary Data2

Pre-registration of the forced guessing paradigm and the informed participants control experiment

Supplementary Data3
Pre-registration of the 20% aware trials control experiment

Supplementary Data4
Pre-registration of the rating control experiment

Supplementary Data5
Pre-registration of the spatial-cueing paradigm auxiliary control with unmasked cues.